APPENDIX 1. POWER AVAILABLE

1. GENERAL. The purpose of this appendix is to provide guidance regarding the power considerations for various kinds of powerplants. The power output of each airplane/engine configuration requires special considerations when determining test day performance corrections and providing the performance expansions for the AFM. The types of powerplants discussed in this appendix are:

a. Reciprocating Engines.

(1) Normally aspirated engine with a fixed pitch propeller;

(2) normally aspirated engine with a constant speed propeller; and

(3) turbocharged engine with a constant speed propeller.

b. Turbopropeller Engines.

2. RECIPROCATING ENGINES.

a. Power Charts. The horsepower being developed by reciprocating engines is usually identified by horsepower charts which are provided by the engine manufacturer. These charts are developed from results of ground runs using a brake-type dynamometer in a test facility and may have no direct correlation to any particular airplane or flight condition. The variations of power with altitude and temperature are the result of theoretical relationships involving air density, fuel/air ratios, etc. These charts nearly always assume a "best power" fuel to air ratio which can rarely be consistently used in service under normal operating conditions. Many installations, for example, intentionally use fuel to air ratios which are on the fuel-rich side of best power so that the engine will not overheat. Providing sufficient cooling air flow over each cylinder to ensure adequate cooling may be more difficult than cooling with a rich fuel mixture. These horsepower charts were also developed while maintaining a constant temperature on each cylinder. This is not possible in service. The charts are developed assuming the following: (1) there is no ram airflow due to movement through the air or; (2) there are no losses due to pressure drops resulting from intake and air filter design; or (3) there are no accessory losses.

b. Chart Assumptions. Regardless of the test stand conditions which are not duplicated in service, it is necessary to assume that each given pressure altitude temperature, engine speed, and manifold pressure combination will result in horsepowers which can be determined from the engine power chart. To accomplish this requires certain procedures and considerations.

c. Tolerances. Each engine power chart specifies a horsepower tolerance from rated horsepower. These are commonly ±2 1/2%; +5%, -2%; or +5%, -0%. This means that with all the variables affecting power being held constant (i.e., constant manifold pressure, engine speed, temperature, and fuel to air ratio), the power could vary this much from engine to engine. For this reason, it is appropriate to account for these variations. Calibration of the test engine(s) by the engine manufacturer is one way of accomplishing this. During engine calibration, the test engine is run on a test stand at the engine manufacturer's facility to identify how it compares with the power output at conditions under which it was rated. The result is a single point comparison to the rated horsepower.

d. Test Day Power.

(1) Calibrated Engines. If an engine, for example, is rated at 200 BHP, the calibration results might show the particular serial numbered engine to develop 198.6 BHP. This is 0.7% below the rated power. For this engine, each of the horsepower values obtained from the engine manufacturer's chart should be adjusted downward by 0.7% to obtain test day horsepower.

(2) Uncalibrated Engines. If the engine is not calibrated, an acceptable method of accounting for the unknown factors is to assume that the test engine is putting out rated horsepower plus the plus tolerance. For example, if the rated horsepower was 350 and the tolerance was $\pm$ 2 1/2%, test day sea level chart horsepower would be assumed to be 350 + .025 (350), or 358.8.

(3) Humidity. Section 23.45(d) requires performance to be based on 80% relative humidity on a standard day. Experience has shown that conditions such as 80% relative humidity on a standard day at sea level have a very small effect on engine power because this condition results in a very low specific humidity. The engine is affected directly by specific humidity (pounds of water per pounds of air) rather than relative humidity. For test day power, dry air should be assumed unless the applicant has an approved method for measuring and determining the effect of humidity.

e. Chart Brake Horsepower. A chart brake horsepower (BHPc) should be determined for expansion of the flight test data in the AFM. BHPc is the horsepower at a particular pressure altitude, manifold pressure and r.p.m. Appropriate inlet temperature corrections should be applied, in accordance with the manufacturer's engine power chart. An 80% relative humidity correction should be applied if the engine manufacturer has an acceptable method and the correction is significant.

f. Variation in Methods. Peculiarities of the various types of reciprocating engines require special considerations or procedures to determine installed power. These procedures are discussed in subsequent paragraphs.

3. NORMALLY ASPIRATED ENGINES WITH CONSTANT SPEED PROPELLERS.

a. Manifold Pressure Versus Altitude. As a first step to determine installed horsepower, flight tests should be conducted to determine manifold pressure versus pressure altitude for the engine installation. The test manifold pressures would be compared to the engine manufacturer's chart values, as shown on figure 1. Figure 1 shows an example of test manifold pressure and chart manifold pressures versus pressure altitude. In this example, the observed manifold pressures are lower than the chart values. This means that the induction system pressure losses exceed the ram pressure rise. An induction system in which manifold pressures exceed the zero ram chart values would reflect an efficient induction system. The term chart brake horsepower indicates that the horsepower values have yet to be corrected for inlet temperature conditions.

b. Example Calculation. The overall corrections to determine installed test day brake horsepower and chart brake horsepower (BHPc) to be used in the expansion of performance would be as follows (refer to figure 1):

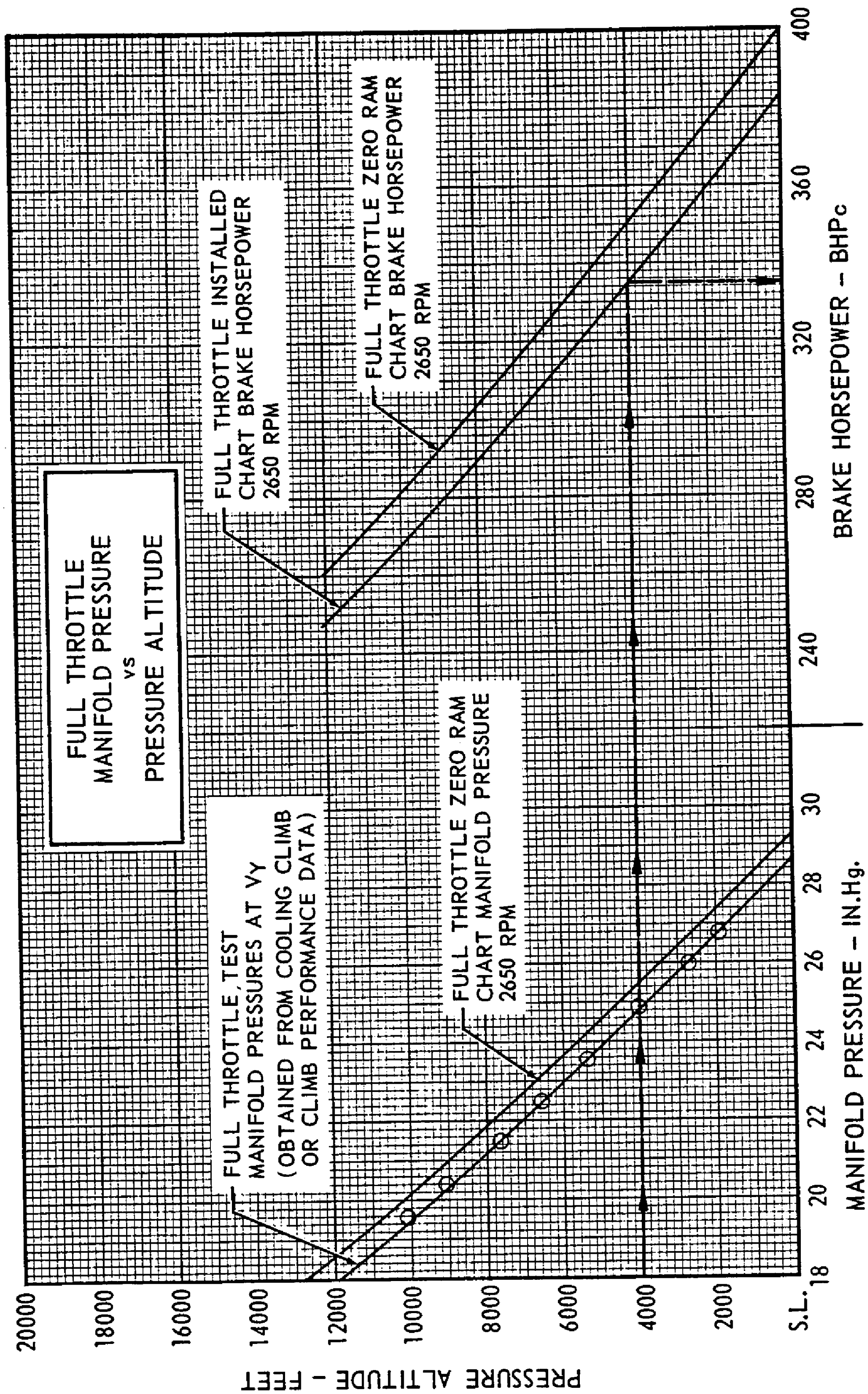

Figure 1 - BRAKE HORSEPOWER VERSUS PRESSURE ALTTITUDE

Known:

Pressure Altitude	- 4,000 feet
Manifold Pressure	- 24.9 in. Hg.
Outside Air Temperature	- $+55^{\circ}F$
Inlet Temperature	- $+63^{\circ}F$
Engine Speed	- 2,650 R.P.M.
Engine Calibration	- -0.7%
Engine Tolerance	- ±2 1/2%

Calculated Test Day BHP for a Calibrated Engine:

Standard Temperature @ 4,000 ft. - $44.7^{\circ}F$

Installed Chart Brake Horsepower (from figure 1) - 335 BHP

Engine Calibration Correction = (335)(-.007) - -2.3 BHP

Correcting for Inlet Temperature

$$\text{Test Day BHP} = (335-2.3)\sqrt{\frac{460+44.7}{460+63.0}} \quad - \quad 326.8 \text{ BHP}$$

Calculated Test Day BHP for an Uncalibrated Engine:

Standard Temperature at 4,000 ft. - $44.7^{\circ}F$

Installed Chart Brake Horsepower (from figure 1) - 335 BHP

Test Day BHP = [335 + .025(335)]

$$\sqrt{\frac{460 + 44.7}{460 + 63}} \quad - \quad 337.3$$

Calculated BHPc for Test Day Density Altitude (Hd):

Hd at 4,000 ft. and $55^{\circ}F$ - 4,670 ft.

Installed BHPc (from figure 1) - 326 BHP

Standard Temperature at 4,670 ft. - $42^{\circ}F$

Correcting for Inlet Temperature Rise

$$\text{BHPc} = 326\sqrt{\frac{460 + 42}{460 + 42 + 8}} \quad - \quad 323.4 \text{ BHP}$$

Calculated BHPc for the AFM Expansion:

For the Same Conditions as Test Day,

BHP (from figure 1) - 335 BHP

Correcting for Inlet Temperature, expansion

$$\text{BHPc} = 335\sqrt{\frac{460+44.7}{460+63}} \quad - \quad 329.1 \text{ BHP}$$

4. TURBOCHARGED ENGINES WITH CONSTANT SPEED PROPELLERS.

a. Manifold Pressure Versus Altitude. From flight tests, it is appropriate to plot manifold pressure versus pressure altitude used to demonstrate satisfactory cooling and climb performance demonstrations. The engine manufacturer's chart brake horsepower should be entered at these manifold pressure values. The result is the chart brake horsepowers to be utilized in data expansion. For some installations, the manifold pressure and fuel flows are limited by the airplane manufacturer's designed schedule. For these, the full throttle values must be identified. Whenever the manifold pressures and fuel flows must be manually set to a schedule, corresponding limitations must be established.

b. Horsepower. Refer to figure 2 for an illustration of manifold pressure and horsepower versus pressure altitude. It is rare for the horsepower values to be constant below the critical altitude. The horsepower ratings are not necessarily limits and it is common to observe chart horsepower values at the intermediate altitudes higher than rated power. As with normally aspirated engines, the term chart brake horsepower indicates that the horsepower values have yet to be corrected for inlet temperature conditions. The corrections for temperature are usually greater for turbocharged than normally aspirated. A 1% decrease in power for each $6^{\circ}F$ increase in temperature above standard temperature conditions at a constant specific fuel consumption (SFC) is common. The apparent effects for a particular installation could be more or less than this. Manufacturer's data for the particular engine should be used.

c. Example Calculation. The overall corrections to determine installed test brake horsepower and brake horsepower to be used in the expansion of performance would be as follows (refer to figure 2):

Known:	Pressure Altitude	-	9,500 feet
	Manifold Pressure	-	44.3 in. Hg.
	Outside Air Temperature	-	$53.0^{\circ}F$
	Compressor Inlet Temperature	-	$67^{\circ}F$
	Engine Speed	-	2,575 R.P.M.
	Engine Calibration	-	+1.7%
	Engine Tolerance	-	$\pm 2\ 1/2\%$

Calculated Test Day BHP for a Calibrated Engine:

Standard Temperature @ 9,500 ft.	-	$25.1^{\circ}F$
Power Correction Due to Temperature at $1\%/6^{\circ}F$ (Temp. rise = $67^{\circ}-25.1^{\circ}F$)	-	-6.98%
Installed Chart Brake Horsepower (from figure 2)	-	351 BHP
Engine Calibration Correction (351)(.017)	-	+5.97 BHP
Test BHP = (351 + 5.97) - (.0698)(356.97)	-	332.1 BHP

Calibrated Test Day BHP for an Uncalibrated Engine:

Standard Temperature at 9,500 ft.	-	$25.1^{\circ}F$
Power Correction at $1\%/6^{\circ}F$	-	-6.98%
Installed Chart Brake Horsepower (from figure 2)	-	351
Test BHP = 351 - (351)(.0698) + 351(.025)	-	335.3

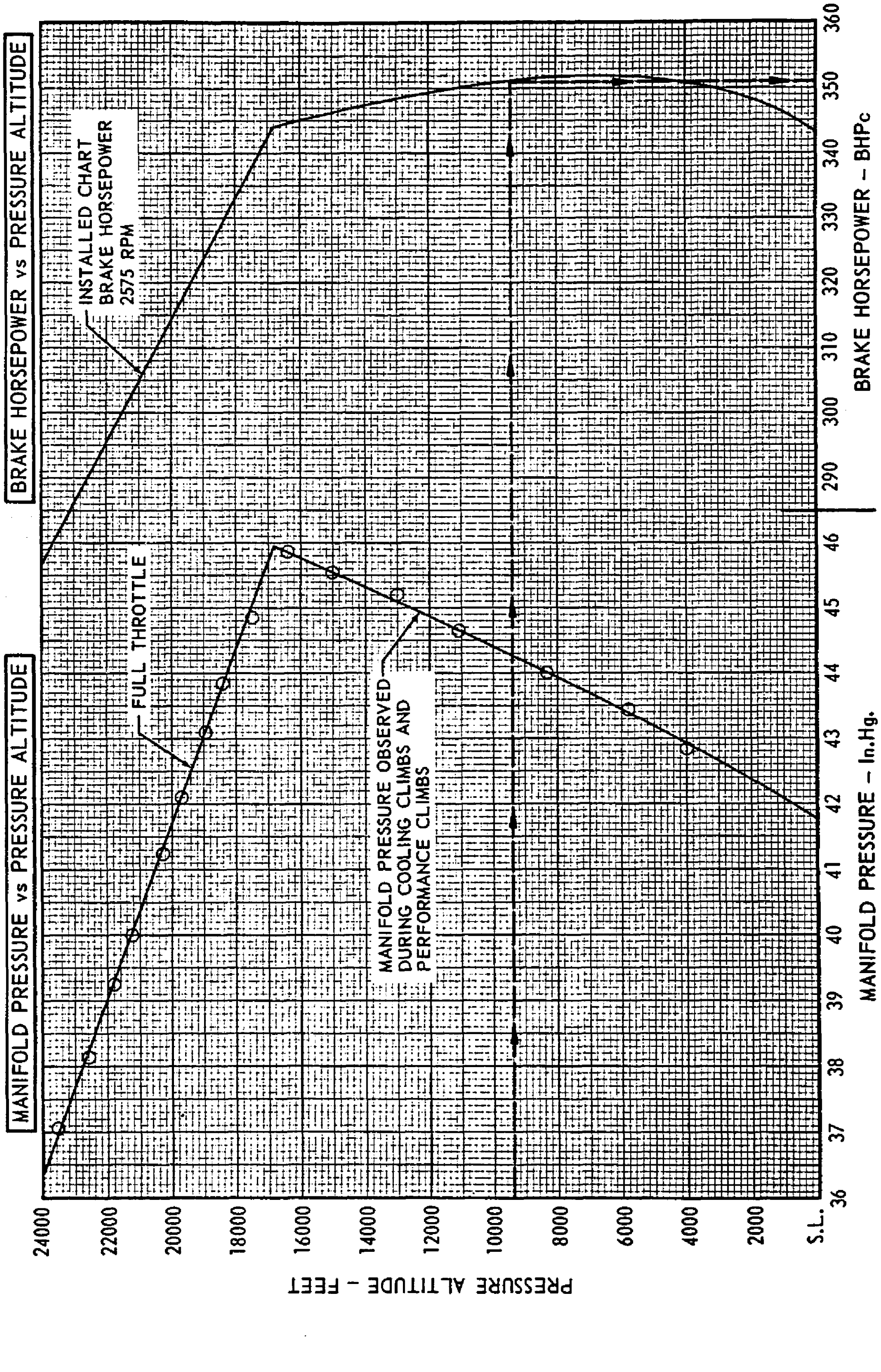

Figure 2 - TURBOCHARGED BRAKE HORSEPOWER VERSUS ALTITUDE

Calculated BHPc for Test Day Density Altitude (Hd):

Hd at 9,500 ft. and 53°F	-	11,280 ft.
Installed BHPc (from figure 2)	-	350 BHP
Power Correction Due to Inlet Temperature Rise at 1%/6°F (temp. rise = 14°F)	-	-2.33%
BHPc = 350-(350)(.0233)	-	341.8 BHP

Calculated BHPc for the AFM Expansion:

For the Same Conditions as Test Day, BHPc (from figure 2)	-	351 BHP
Temperature correction to BHPc = 351 - (.0698)(351)	-	326.5 BHP

5. <u>NORMALLY ASPIRATED ENGINES WITH FIXED PITCH PROPELLERS. (RESERVED)</u>.

6. <u>TURBOPROPELLER ENGINES</u>.

a. <u>Power Measurement</u>. Turbopropeller engines are gas turbine engines which turn a propeller. Power output is a function of exhaust gas temperature or turbine interstage temperatures. Torque is measured by an integral torque measuring device which can be related directly to shaft horsepower output. Torque pressure is typically obtained by a slip ring or strain gauge arrangement which has been calibrated to indicate torque. Torque values with the associated propeller shaft r.p.m. are used to calculate shaft horsepower. Shaft horsepower differs from brake horsepower in that shaft implies the power being developed at the propeller shaft. The total thrust horsepower (sometimes called equivalent thrust horsepower) is a combination of propeller shaft horsepower times propeller efficiency plus the effect of the net exhaust thrust.

b. <u>Power Available</u>. The prediction of power available is obtained from the engine manufacturer as a computer program. Each installation must be evaluated to identify:

Generator Loads (all engine and one engine inoperative)
Bleed Air Extractions (with and without ice protection)
Accessory Pad Extractions
Engine Air Inlet Efficiency (with and without ice protection)
Engine Exhaust Efficiency
Effect of Specific Humidity

With these values as input to the computer program, installed power available and fuel flows at various airspeeds, temperatures, and altitudes can be calculated.

APPENDIX 2. CLIMB DATA REDUCTION

1. DRAG POLAR METHOD. This is one method to develop the airplane's drag polar equation directly from climb flight test data. It is a simplified method which assumes climb speeds where the compressibility drag is negligible (usually Mach numbers below 0.6), climb angles of less than 15^{o}, and no propeller slipstream effects on the wing lift and drag characteristics.

a. Cautions. Propeller airplanes are susceptible to slipstream drag and all airplanes are susceptible to trim drag. This is most noticeable on airplanes with wing-mounted engines and when one engine is inoperative. Care should be given so that drag results are not extended from one flight condition to another. Examples of this are:

(1) Drag obtained in level cruise configuration cannot be extended to a climb configuration.

(2) Two-engine climb data cannot be extended to the one-engine-inoperative case.

In summary, the power and trim conditions must remain very close to those existing for the actual test conditions. Drag results are only as accurate as the available power information and propeller efficiency information. The cooling airflow through the engine is also a factor.

b. Calculation of C_D and C_L. Flight test data for various climb airspeeds, weights and altitudes should be used to calculate C_D and C_L. The equations are as follows:

$$C_D = \left[BHP_T \; (\eta_p) - \frac{T_{AT}}{T_{AS}} \; \frac{(AF)(R/C_O \;\; W_T)}{33{,}000} \right] \left[\frac{96209\sqrt{\sigma}}{(V_e)^3 \, S} \right]$$

$$C_L = \frac{295 \; (W_T) \sqrt{1 - \left[\frac{\sqrt{\sigma}}{(101.27 V_c)} \; \frac{T_{AT}}{T_{AS}} \; (AF) R/C_O \right]^2}}{(V_e)^2 \; S}$$

Where: BHP_T = test day horsepower (see appendix 1)

η_p = propeller efficiency (obtain from propeller manufacturer or may be estimated)

T_{AT} = test air temperature - ^{o}Kelvin

T_{AS} = standard air temperature - ^{o}Kelvin

R/C_O = observed rate of climb - feet/minute

W_T = airplane test weight - pounds

V_e = equivalent airspeed - knots

S = wing area - square feet

σ = atmospheric density ratio (see appendix 7, figure 1)

AF = acceleration factor (may be insignificant at lower speeds)

$$AF = \frac{(1 + 0.2M^2)^{3.5} - 1}{(1 + 0.2M^2)^{2.5}} - 0.133M^2 + 1$$

Where: M = Mach number,
V_C is constant,
altitude below 36,089 feet

c. Data Plotting. Once C_D and C_L are calculated from various climb tests at many altitudes, weights, and airspeeds, a plot is made of C_D versus C_L^2. This choice of parameters reduces the parabolic drag polar (C_L vs. C_D) to a straight line relationship. These procedures should be used to establish C_{DP} and e for each configuration that climb data is obtained.

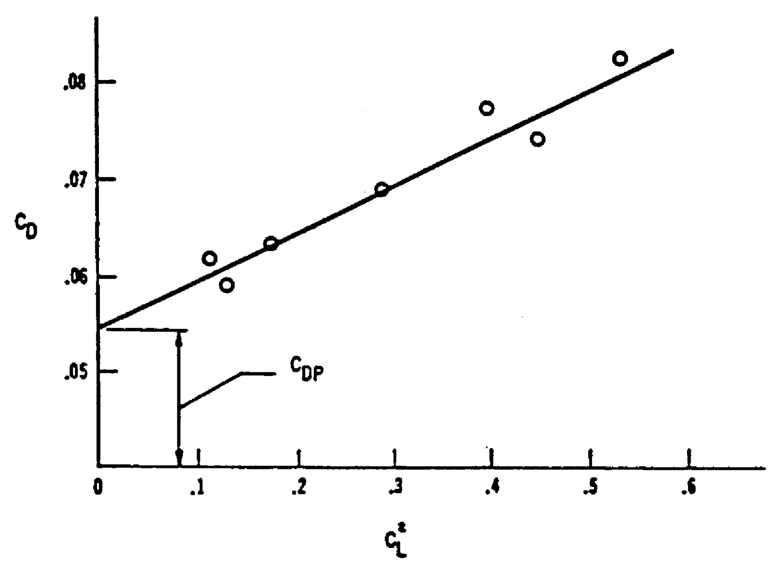

Figure 1 - COEFFICIENT OF DRAG VERSUS COEFFICIENT OF LIFT

From this plot the profile drag coefficient (C_{DP}) can be determined graphically and Oswald's efficiency factor (e) can be calculated.

$$e = \frac{C_L^2}{\left(C_D - C_{DP}\right) 3.1416 \left(\frac{b^2}{S}\right)} \quad \text{or} \quad e = \frac{\Delta C_L^2 / \Delta C_D}{3.1416 \left(\frac{b^2}{S}\right)}$$

Where: b = wing span - feet
S = wing area - square feet

d. Standard Day Correction. Since the C_L^2 vs. C_D data was developed from test day conditions of weight, altitude, temperature, and power, calculations will be required to determine standard day conditions.

$$R/C = \frac{(THP_A - THP_R)\ 33{,}000}{W_C\ (AF)}$$

Where: THP_A = thrust horsepower available

THP_R = thrust horsepower required

W_C = aircraft weight to which correction is to be made (pounds)

AF = acceleration factor (see paragraph b)

$$THP_A = BHPc\ (\eta_p)$$

Where: BHPc = chart brake horsepower at test day density altitude (see appendix 1)

η_p = propeller efficiency

$$THP_R = \frac{\sigma (V_T)^3 \quad C_{DP} \quad S}{96209} + \frac{(0.2883) \quad (W_C)^2}{e\,\sigma\, b^2 \quad V_T}$$

Where: σ = atmospheric density ratio

V_T = true airspeed - knots

C_{DP} = profile drag coefficient

S = wing area - square feet

e = efficiency factor

b = wing span - feet

W_C = aircraft weight to which correction is to be made - pounds

e. Expansion to Nonstandard Conditions. The methods in paragraph d can be used to expand the climb data by choosing weight, altitude, temperature, and the corresponding power available.

f. References. The following references may be of assistance in cases where compressibility drag is a factor, climb angles are greater than 15°, or if the reader wishes to review the basic derivations of the drag polar method:

(1) "Airplane Aerodynamics and Performance" by C. Edward Lan and Jan Roskam. Published and sold by:

Roskam Aviation and Engineering Corporation
Route 4, Box 274
Ottawa, Kansas 66067

(2) Air Force Technical Report No. 6273, "Flight Test Engineering Handbook," by Russel M. Herrington, et. al., dated May 1951. Corrected and revised June 1964-January 1966. Refer to NTIS No. AD 636 392. Available from:

National Technical Information Service (NTIS)
P.O. Box 1553
Springfield, Virginia 22151

2. DENSITY ALTITUDE METHOD. This method is an alternate to the Drag Polar Method. The Density Altitude Method is subject to the same cautions as the Drag Polar Method. Item numbers 1, 2, 6, 9, 12, 17, 18, and 19 are observed during flight tests and the remaining items are calculated.

Item No.	Item
1	Pressure Altitude (Hp) -- feet
2	Outside Air Temperature -- $^{\circ}$F
3	Atmospheric Density Ratio -- σ
4	Density Altitude (Hd) -- feet. $Hd = 145539 \left[1-(\sqrt{\sigma})^{.4699}\right]$
5	Std. Temp. @ Hp (Ts) -- $^{\circ}$F + 460
6	IAS -- knots
7	CAS -- knots
8	TAS = $7 / \sqrt{3}$
9	Observed rate of climb -- ft./min.
10	T/Ts = $(2 + 460)/5$

Item No.	Item
11	Actual R/C = (9) x (10)
12	Test Weight, w -- lbs.
13	$\Delta R/C_{\Delta w} = (11) (1 - (12) /Wc)$
	where Wc = aircraft weight to which correction is to be made
14	$q \pi e b^2 = (7)^2 \pi e b^2/295$
	where b = wing span in feet e = Oswald's efficiency factor (0.8 may be used if a more exact value cannot be determined)
15	$\Delta D_i = (Wc^2 - (12)^2) / (14)$
16	$\Delta (R/C) \Delta D_i = 101.27 \ (15) \ (8) /Ws$
17	Calibrated RPM (reciprocating engine)
18	Calibrated MP (reciprocating engine)
19	Inlet air temperature
20	Test day BHP corrected for temperature from appendix 1 at Hp
21	BHPc corrected for temperature from appendix 1 at Hd
22	ηp -- propeller efficiency (obtain from propeller manufacturer or may be estimated)
23	$\Delta THP = (22) ((21) - (20))$
24	$\Delta (R/C) \Delta_p = (23) \times 33,000 /Wc$
25	$R/C_{std} = (11) - (13) - (16) + (24)$

Items 4, 7, and 25 are used to plot figure 25-2.

APPENDIX 3. MINIMUM CONTROL SPEED EXTRAPOLATION TO SEA LEVEL

1. GENERAL. The purpose of this appendix is to identify one method of extrapolating minimum control speeds (V_{MC}) observed during flight tests, to sea level, standard temperature conditions. There is a geometrical relationship between the yawing moment about the center of gravity caused by the operating engine, and the rudder deflection necessary to offset this tendency and cause an equilibrium.

2. CALCULATION METHOD. This method involves calculating a geometric constant (C_2) for each observed test value, averaging the results, and calculating a sea level V_{MC}. The equations are as follows:

$$V_{MC} = [\ (C_2)\ (\sqrt{\sigma})\ (THP)\ ]^{1/3}$$

or;

$$C_2 = \frac{V_{MC}^{\ 3}}{(\sqrt{\sigma})\ (THP)}$$

Where: C_2 = a geometric constant

$\sqrt{\sigma}$ = the square root of the density ratio

THP = thrust horsepower (test shaft horsepower or brake horsepower times propeller efficiency)

3. CAUTIONS AND ASSUMPTIONS. This method has the following associated cautions and assumptions:

a. This method is limited to airplanes with a V_{MC} due to lack of directional control. Each test value of V_{MC} must be observed with full rudder. If, for example, the test conditions result in reaching the force limit (150 pounds rudder force) prior to achieving full rudder deflection, then observed V_{MC} values would require special consideration.

b. The effects of wing lift in the 5° bank angle are ignored.

c. Do not use this method for fixed-pitch or windmilling propellers.

d. Any altitude effects which may result from windmilling propeller drag on the inoperative engine have been ignored.

e. Computing a V_{MC} value at sea level involves raising to the power of 1/3 (use .33333333). The number of significant digits used affects the resulting computations. For this reason, use at least 8 significant digits.

f. Propeller efficiencies should be reasonable. They may be obtained from propeller efficiency charts provided by the propeller manufacturer, or from other acceptable sources.

4. SAMPLE CALCULATIONS. Test data from a two-engine turbopropeller airplane have been used for illustration. Observations for one takeoff flap setting are presented. The procedures should be repeated for each additional approved takeoff flap setting. Table 1 presents five data points which were collected at various altitude and temperature conditions, and the resulting C_2 values which were calculated. For these tests, the inoperative propeller was feathered (auto-feather available).

Table 1 - FLIGHT TEST DATA

	OBSERVED					CALCULATED			
RUN	PRESSURE ALTITUDE (FEET)	O.A.T. (^{o}F)	TORQUE (FT-LB)	PROPELLER RPM	V_{MC} (KCAS)	$\sqrt{\sigma}$	SHAFT HORSE-POWER (1)	η_p (2)	C_2
1	3500	86.3	3219	1700	91.2	.9142439	1041.95	.590	1349.657
2	4200	88.3	3219	1700	91.2	.900795	1041.95	.585	1381.516
3	4800	87.3	3219	1700	90.7	.8915881	1041.95	.580	1384.786
4	5500	85.2	3219	1700	90.7	.881668	1041.95	.575	1412.544
5	6300	83.2	3219	1700	90.7	.8700833	1041.95	.570	1443.907

(1) Calculated from observed torque and propeller r.p.m.
(2) Obtained from propeller manufacturer.

The propeller efficiencies were obtained from a power coefficient versus advance ratio map which was obtained from the propeller manufacturer. The 4-blade propellers were assumed for these calculations to have an activity factor = 80; and an integrated lift coefficient = 0.700.

The five C_2 values from table 1 were averaged as 1394.482. The sea level, standard temperature maximum shaft horsepower was 1050. At low speeds, the propeller efficiency changes fairly significantly with speed. For this reason, it is appropriate to determine propeller efficiencies at several speeds near the estimated sea level V_{MC} value. Table 2 presents the thrust horsepower values determined for calibrated airspeeds of 90, 95, 100, and 105 knots and the V_{MC} values calculated using these thrust horsepower values and the average C_2 (1394.482).

Figure 1 illustrates the plot of airspeed versus thrust horsepower. One curve is of thrust horsepower available versus airspeed. The other represents the calculated V_{MC} values versus thrust horsepower available at sea level. The intersection of the two curves represents the V_{MC} value associated with sea level, standard temperature conditions. These calculations resulted in a final V_{MC} value of 98.8 knots calibrated airspeed.

Table 2 - TABULATED THRUST HORSEPOWER AVAILABLE AND CALCULATED V_{MC}

V_C (KCAS)	SHAFT HORSEPOWER	η_p	THRUST HORSEPOWER AVAILABLE AT SEA LEVEL	CALCULATED V_{MC} C_2 = 1394.482
90	1050	.610	640.5	96.3
95	1050	.640	672.0	97.9
100	1050	.665	698.25	99.1
105	1050	.688	722.4	100.2

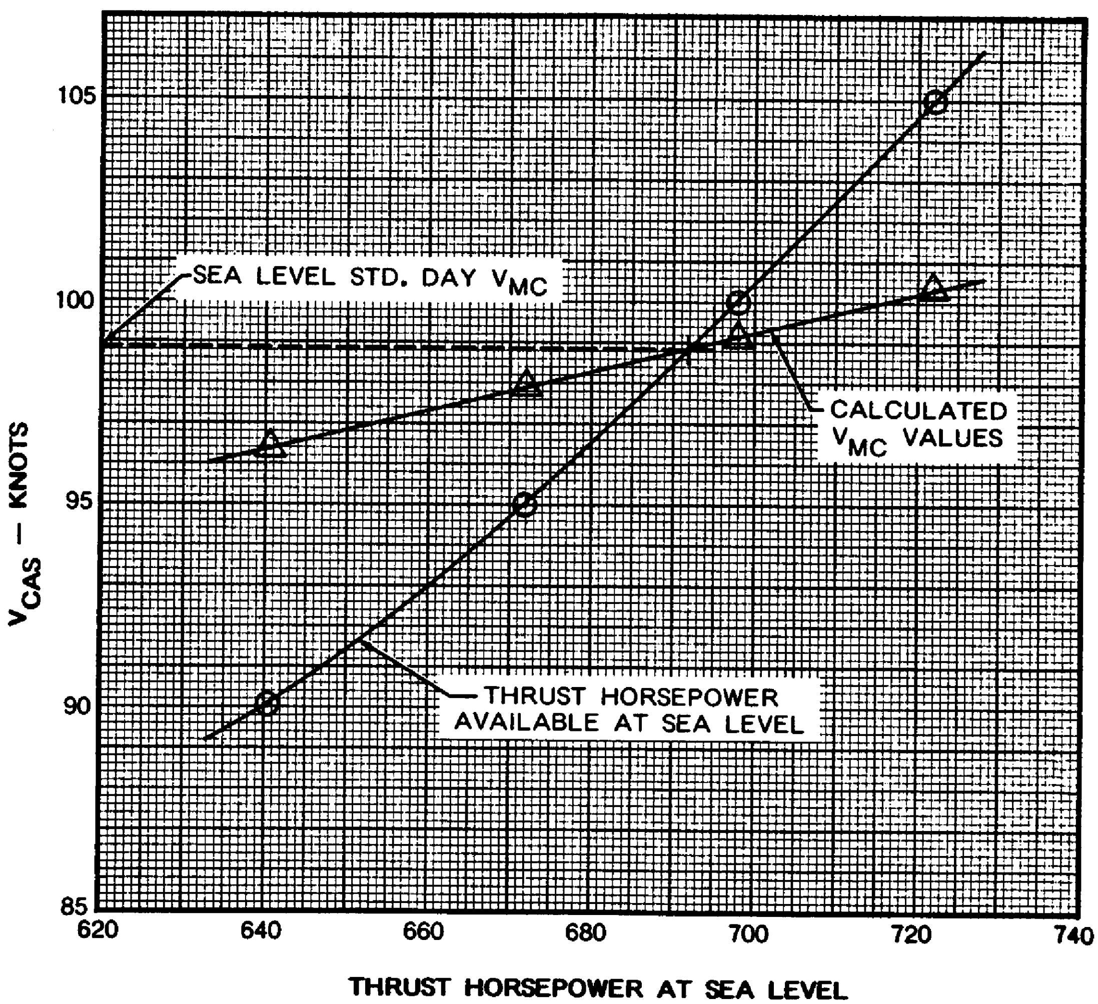

Figure 1 - THRUST HORSEPOWER AT SEA LEVEL

APPENDIX 4. FAR 23 MANUALS, MARKINGS & PLACARDS CHECKLIST

PRIMARY FAR	SUPPORT FAR	DESCRIPTION	MAN-UAL	MARK	PLA-CARD	AMENDMENT NO.
23.25(a)(2)	23.1557(b)	Occupant weight less than 170 lbs normal or 190 lbs. utility & acrobatic			X	21
23.31(b)	23.1557(a)	Placement of removable ballast Ballast-content and weight limitations	X	X	 X	13
23.221(c)(2)	23.1541(a)(2)	Prohibited spins with flaps extended			X	7
23.671(b)		Identify controls		X		Orig.
23.677(a)		Direction and position of trim device		X		7
23.685(d)		Marking of control system elements		X		17
23.733(b)		Marking of specially constructed tires		X		17
23.777(a)	23.1555(a)	Identify cockpit controls		X		7
23.785(d)		Seats in util. and acro. airplanes which won't accommodate parachute			X	23
23.807(b)(3)		Emergency exit location & operation		X		10
23.841(b)(7)		Warning-max. differential cabin pressure and landing loads exceed limit			X	17
23.853(c)		Smoking prohibited in personnel compartments if applicable			X	25
23.903(d)	23.1581(a)(2)	Piston engine start technique and limitations	X		X	26

FAR 23 MANUALS, MARKINGS & PLACARDS CHECKLIST

PRIMARY FAR	SUPPORT FAR	DESCRIPTION	MAN-UAL	MARK	PLA-CARD	AMENDMENT NO.
23.903(e)(1)	23.1581(a)(2)	Turbine engine start techniques and limitations	X		X	26
23.903(e)(3)	23.1581(a)(2)	Turbine engine inflight restart techniques and limitations	X		X	26
23.955(d)(2)	23.1555(c)(3)	Aux. fuel tank usage, if required			X	7
23.973(a)	23.1557(e)	Fuel tank filler		X		18
23.1001(g)		Adverse configurations for jettisoning fuel, if applicable			X	7
23.1013(c)	23.1557(c)	Oil tank filler connections		X		15
23.1061(c)	23.1557(c)	Coolant tank filler connection		X		Orig.
23.1141(a)	23.1555(a)	Powerplant control marking		X		18
23.1301(b)		Label equipment for identification, function or operating limitations		X		20
23.1325(b)(3)	23.1541(a)(2)	Alternate static correction card, if required		X		20
23.1327(b)	23.1547(e)	Magnetic indicator deviations of more than 10 degrees			X	20
23.1329(c)		Direction of motion for autopilot controls		X		23
23.1337(b)		Mark fuel quantity either pounds or gallons		X		18

FAR 23 MANUALS, MARKINGS & PLACARDS CHECKLIST

PRIMARY FAR	SUPPORT FAR	DESCRIPTION	MAN-UAL	MARK	PLA-CARD	AMENDMENT NO.
23.1357(d)		Identify essential circuit breakers or fuses		X		20
23.1367(d)		Label switches for operation and circuit controlled		X		Orig.
23.1419(a)	23.1585(a)	Ice Protection equipment operation	X			14
23.1450(c)		Oxygen flow, duration & heat warning			X	20
23.1541(a) and (b)	23.1545 thru 23.1567	Requires and specifies characteristics of markings and placards		X	X	21
23.1541(c)		For multicategory airplanes - requires one category basis for markings and placards and AFM	X	X	X	21
23.1543		Alignment and visibility of instrument markings		X		Orig.
23.1545(b)		Requires airspeed indicators marked for: (1) red radial line for V_{NE} (2) yellow arc for caution range (3) green arc for normal operating range (4) white arc for flap operating range (5) blue arc for V_y, one-engine inoperative (6) red radial line for V_{MC}		X		23
23.1545(c)		Means to indicate variation with altitude of V_{NE} or V_{NO}		X		23

FAR 23 MANUALS, MARKINGS & PLACARDS CHECKLIST

PRIMARY FAR	SUPPORT FAR	DESCRIPTION	MAN-UAL	MARK	PLA-CARD	AMENDMENT NO.
23.1545(d)		If applicable, show variation of V_{MO}/ M_{MO} with altitude or compressibility limitations or red radial line for lowest V_{MO}/M_{MO} up to maximum altitude		X		23
23.1547	23.1327	Conditions for, and calibration of, magnetic direction ind.			X	20
23.1549		Powerplant instrument (1) red radial line—maximum & minimum operating limits (2) green arc - normal range (3) yellow arc - caution & takeoff (4) red arc - restricted range vibration		X		12
23.1551		Oil quantity indicator increments		X		Orig.
23.1553		Red arc for unusable, fuel, if applicable		X		Orig.
23.1555(a)		Cockpit controls for function and method of operation		X		21
23.1555(b)		Secondary controls marked		X		21
23.1555(c)(1)		Fuel selector position		X		21
23.1555(c)(2)		Fuel tank sequence		X		21
23.1555(c)(3)		Conditions for use of fuel from restricted usage tank			X	21
23.1555(c)(4)		Multiengine fuel selector position		X		21

FAR 23 MANUALS, MARKINGS & PLACARDS CHECKLIST

PRIMARY FAR	SUPPORT FAR	DESCRIPTION	MANUAL	MARK	PLACARD	AMENDMENT NO.
23.1555(d)(1)		Usable fuel marked at indicator, if applicable		X		21
23.1555(d)(2)		Usable fuel marked on selector, if applicable		X		21
23.1555(e)(1)		Landing gear position indicator marking		X		21
23.1555(e)(2)		All emergency controls must be red and method of operation marked		X		21
23.1557(a)		Baggage, cargo and ballast location placards for weight and content			X	23
23.1557(b)		Seats less than 170 lbs.			X	23
23.1557(c)		Fuel filler openings		X		23
23.1557(d)		Emergency exit placards and controls			X	23
23.1557(e)		External power plug markings		X		23
23.1557(f)		Unusable fuel placard by fuel quantity indicator			X	23
23.1559(a)(1)		Operating limitations - single category			X	21
23.1559(a)(2)		Operating limitations - multicategory			X	21
23.1559(b)		Kinds of operation			X	21
23.1561		Method of operation and stowage of safety equipment		X		Orig.

FAR 23 MANUALS, MARKINGS & PLACARDS CHECKLIST

PRIMARY FAR	SUPPORT FAR	DESCRIPTION	MAN-UAL	MARK	PLA-CARD	AMENDMENT NO.
23.1563		V_A and V_{LO} near airspeed indicator			X	7
23.1567		Flight maneuvers 1. Normal - prohibits acrobatics 2. Utility - lists approved acro. maneuvers & entry speeds <u>or</u> spins prohibited 3. Acrobatic - lists approved acro. maneuvers and entry speeds a. prohibits inverted if not approved			X	21
23.1581	23.1583 thru 23.1589	1. Requires AFM 2. Requires any other info necessary for safe operation	X			21
23.1583(a)	23.1545	Requires information for marking airspeed indicator per 23.1545 and V_A, V_{LE} and V_{LO} and their significance	X			23
23.1583(b)	23.1521 23.1549 thru 23.1553	Info explaining powerplant limitations and instrument markings	X			23
23.1583(c)		Maximum weight and maximum landing weight if less than maximum	X			23
23.1583(d)		Center of gravity limits	X			23
23.1583(e)(1)	23.221	Acrobatics prohibited. Statement "incapable of spinning" if applicable; otherwise placard against spins	X		X	23

FAR 23 MANUALS, MARKINGS & PLACARDS CHECKLIST

PRIMARY FAR	SUPPORT FAR	DESCRIPTION	MANUAL	MARK	PLACARD	AMENDMENT NO.
23.1583(e)(2)	23.221	Authorized maneuvers and entry speeds. Statement "Incapable of spinning" if applicable	X			23
23.1583(e)(3)		Authorized maneuvers and entry speeds. spin recovery placard	X		X	23
23.1583(f)		Positive limit load factor in g's	X			23
23.1583(g)		Number and function of minimum flight crew, if more than one	X			23
23.1583(h)		Kinds of operation and meteorological conditions and listing of installed equipment affecting limitations identified as to function	X			23
23.1583(k)	23.1527	Maximum operating altitude	X			23
23.1583(l)		Maximum passenger seating configuration	X			23
23.1585(a)		Information concerning: 1. Normal and emergency procedures 2. Demonstrated crosswind velocity 3. Operation in crosswind 4. Airspeeds, procedures and info pertinent to use of: a. Recommended climb speed & variation with altitude b. V_X and variation with altitude c. Approach speeds and speeds for transition to balked landing	X			23

FAR 23 MANUALS, MARKINGS & PLACARDS CHECKLIST

PRIMARY FAR	SUPPORT FAR	DESCRIPTION	MAN-UAL	MARK	PLA-CARD	AMENDMENT NO.
23.1585(c)	23.51	1. All engine takeoff procedures 2. Multiengine airplane info concerning one-engine-inoperative procedures for a. Maintaining or recovering control at speeds $\pm V_{MC}$ b. Landing & go-around, if safe, or warning against attempting go-around c. Obtaining best performance including effects of configuration	X			23
23.1585(d)	23.953	Multiengine info identifying operating conditions when fuel system independence is necessary for safety and instructions for placing fuel system in that configuration	X			23
23.1585(e)	23.1353	Procedures for disconnecting battery from charging source, if applicable	X			23
23.1585(f)		Unusable fuel if applicable	X			23
23.1585(g)		Usable fuel in each tank	X			23
23.1587(a)(1)	23.201(b)	Loss of altitude of more than 100 ft. or nose down pitch more than 30° during stall recovery	X			21
23.1587(a)(2)		Condition for total usable fuel	X			21
23.1587(a)(3)		V_{SO} at maximum weight	X			21
23.1587(a)(4)		V_{S1} gear & flaps up at bank angles up to 60°	X			21

FAR 23 MANUALS, MARKINGS & PLACARDS CHECKLIST

PRIMARY FAR	SUPPORT FAR	DESCRIPTION	MAN-UAL	MARK	PLA-CARD	AMENDMENT NO.
23.1587(a)(5)	23.51	Takeoff distance; speed at 50' ht., configuration, kind of surface, use of cooling and flight path control devices & landing gear retraction usage	X			21
23.1587(a)(6)	23.75	Landing distance; configuration, kind of surface, and flight path control devices	X			21
23.1587(a)(7)	23.65 23.77	Steady rate or gradient of climb: Airspeed, power, configuration	X			21
23.1587(a)(8)		Calculated approximate effect on takeoff distance, landing distance and rate of climb, of variations in 1. altitude, S.L. to 8000' 2. temperature, S.L. to 8000', ISA, $-60^{o}+ 40^{o}F$	X			21
23.1587(a)(9)	23.1041 thru 23.1047	For recip. engines, max. temp. for cooling	X			21
23.1587(b)		Approximate degradation of climb performance with skis on fixed gear landplanes, not to be "critical" and not to exceed 30 to 50 feet per minute	X			21
23.1587(c)(1)	2.205	One-engine-inoperative stall altitude loss and pitch angle	X			21
23.1587(c)(2)	23.67	One-engine-inoperative best climb or minimum descent speed	X			21

FAR 23 MANUALS, MARKINGS & PLACARDS CHECKLIST

PRIMARY FAR	SUPPORT FAR	DESCRIPTION	MANUAL	MARK	PLACARD	AMENDMENT NO.
23.1587(c)(3)	23.1047	One-engine-inoperative cooling climb speed, if required	X			21
23.1587(c)(4)	23.67	One-engine-inoperative rate or gradient of climb: airspeed, power & configuration	X			21
23.1587(c)(5)	23.67	Calculated approximate effect on steady rate of climb of variation in 1. Altitude at sea level and 8000', ISA, cruise configuration 2. Temperature at sea level and 8000', ISA -60^{o} to $+ 40^{o}F$	X			21
23.1589(a)	23.25	Weight and location of each item of equipment installed	X			Orig.
23.1589(b)	23.25	Loading instructions for load conditions between minimum and maximum weight which could put c.g. out of limits selected by applicant, for structure, or for functional requirement compliance	X			Orig.
FAR 23 Appendix E (a)(2)		Increased weight allowed with standby power and Administrator's operating limitations (if nec.) and prohibition to operate at high weight when standby power stored too long or expended	X	X	X	2

APPENDIX 5. GUIDE FOR PREPARING AIRPLANE FLIGHT MANUAL AND PILOT'S OPERATING HANDBOOK SUPPLEMENTS

1. INTRODUCTION. An applicant is responsible for preparing an Airplane Flight Manual (AFM) supplement when the airplane has been modified in such a manner that limitation, procedures, performance, or loading instructions have changed. The supplement should be prepared to reflect this supplemental information. If there is no change in one of the sections, it should so state.

a. Pilot's Operating Handbook Supplements. Refer to GAMA Specification No. 1, Revision No. 1.

b. AFM Supplements. Refer to paragraph 2 below and sample AFM.

2. GENERAL.

a. Enter name and address of applicant and document number (if used).

b. Enter make and model of the airplane. Multiple models may be used.

c. Enter registration number. Note: if more than one airplane is to be approved under this supplemental type certificate, leave this space blank on the master copy of the supplement so it can be filled in for each airplane as the modification is accomplished.

d. Enter airplane serial number. This number is on the airplane data plate. Note: If more than one airplane is to be approved under this supplemental type certificate, leave this space blank on the master copy of the supplement so it can be filled in for each airplane as the modification is accomplished. If only one airplane is to be approved, add "only" after the serial number.

e. Enter original AFM date or reissue date (if applicable).

f. Enter the type of modification or equipment installed.

g. Enter approval basis such as: Form 337, specification item number, Supplemental Type Certificate Number, etc.

h. Enter any changed or additional limitations as a result of the modification. Follow the format of the basic AFM. If no change, state "NO CHANGE."

i. Enter any change in or additional procedures as a result of the modification. Follow the format of the basic AFM. This section may be divided into Normal and Emergency Procedures, if necessary. If no change, state "NO CHANGE."

j. Enter any change in performance as a result of the modification. If no change, state "NO CHANGE." In some cases it is possible to show a statement similar to the following, "The performance of this airplane equipped with the Continental E-225-8 engine and Beech Model 215 propeller is equal to or better than the performance as listed in the original FAA-approved AFM.

k. Copy this item as shown on the sample AFM Supplement leaving a blank space for typing of the ACO Manager's name below the signature line.

l. Type as shown on sample AFM Supplement leaving a blank space so date of approval can be added.

m. If the supplement requires more than one page, each page should have: (1) the name and address of applicant and document number; (2) AFM supplement for Make and Model; (3) "FAA-approved" and "date" of approval, and (4) page number as (Page 1 of 3).

n. For those airplanes without flight manuals, and placards are not appropriate, the document should be labeled a Supplemental Flight Manual and arranged and worded as necessary with reference to the appropriate markings and placards. Identification of the material as Limitations, Procedures, or Performance should be clearly presented.

o. If applicant revises the AFM supplements, pertaining to one airplane model, a log of revisions may be added, as follows:

LOG OF REVISIONS

Revision No.	Pages Affected	Description	FAA-Approved	Date

p. Vertical bars should be placed in the margin of the revised pages to indicate changed material.

Name ______________________ (a)

Address ______________________

Supplement No. ______________________

FAA-APPROVED

AIRPLANE FLIGHT MANUAL SUPPLEMENT

FOR

_______(b)_______
Make and Model Airplane

Reg. No. ___(c)___

Ser. No. ___(d)___

This supplement must be attached to the FAA-approved Airplane Flight Manual dated ____(e)____ when ______(f)______ is installed in accordance with ________(g)________. The information contained in this document supplements or supersedes the basic manual only in those areas listed. For limitations, procedures and performance information not contained in this supplement, consult the basic airplane flight manual.

I. LIMITATION: (h)

II. PROCEDURES: (i)

III. PERFORMANCE: (j)

FAA-Approved ______(k)______

Manager, Aircraft Certification Office
Federal Aviation Administration
City, State

DATE ______________
(l)

Revised ______________
(If applicable)

Page 1 of ______________
(m)

APPENDIX 6. SAMPLE KINDS OF OPERATING EQUIPMENT LIST

This airplane may be operated in day or night VFR, day or night IFR, and known or forecast icing conditions when the appropriate equipment is installed and operable.

The following equipment list identifies the systems and equipment upon which type certification for each kind of operation was predicated. The following systems and items of equipment must be installed and operable for the particular kind of operation indicated.

The ATA numbers refer to equipment classifications of Air Transport Association Specification Code 100.

	VFR Day	VFR Night	IFR Day	IFR Night	Icing Conditions
Communications (ATA-23)					
1. Communication Radio (VHF)	0	0	1	1	1
Electrical Power (ATA-24)					
1. Battery	1	1	1	1	1
2. D. C. Generator	2	2	2	2	2
3. D. C. Loadmeter	2	2	2	2	2
4. D. C. Generator Warning Light	2	2	2	2	2
5. Inverter	2	2	2	2	2
6. Inverter Warning Light	1	1	1	1	1
7. Feeder Limiter Warning Light	1	1	1	1	1
8. Battery Monitor System	1	1	1	1	1
9. AC Volt Meter	1	1	1	1	1
Equipment/Furnishings (ATA-25)					
1. Exit Signs - Self-Illuminated	4	4	4	4	4
Fire Protection (ATA-26)					
1. Engine Fire Detector System	2	2	2	2	2
2. Firewall Fuel Shutoff System	2	2	2	2	2

	VFR Day	VFR Night	IFR Day	IFR Night	Icing Conditions
Flight Controls (ATA-27)					
1. Flap System	1	1	1	1	1
2. Flap Position Indicator	1	1	1	1	1
3. Horizontal Stabilizer Trim System - Main	1	1	1	1	1
4. Horizontal Stabilizer Trim System - Standby	1	1	1	1	1
5. Stabilizer out-of-trim Aural Warning Indicator	1	1	1	1	1
6. Trim-in-Motion Aural Indicator	1	1	1	1	1
7. Horizontal Stabilizer Position Indicator	1	1	1	1	1
8. Stall Warning Horn	1	1	1	1	1
9. Trim Tab Indicator - Rudder	1	1	1	1	1
10. Trim Tab Indicator Aileron	1	1	1	1	1
Fuel (ATA-28)					
1. Fuel Boost Pumps (4 are installed)	PER	AFM	Limitations		
2. Fuel Quantity Indicator	2	2	2	2	2
3. Fuel Quantity Gauge Selector Switch	1	1	1	1	1
4. Nacelle Not-Full Warning Light	2	2	2	2	2
5. Crossfeed Light	1	1	1	1	1
6. Fuel Boost Pump Low Pressure Warning Light	2	2	2	2	2
7. Fuel Flow Indicator	2	2	2	2	2
8. Jet Transfer Pump	2	2	2	2	2
Ice and Rain Protection (ATA-30)					
1. Engine Inlet Scoop Deicer Boot	2	2	2	2	2
2. Indicator - Propeller/Inlet Deicer	1	1	1	1	1
3. Engine Inertial Anti-Icing System	2	2	2	2	2
4. Pitot Heat	0	0	2	2	2
5. Alternate Static Air Source	0	0	1	1	1
6. Engine Auto-Ignition System (if installed)	2	2	2	2	2
7. Propeller Deicer System	0	0	0	0	1
8. Windshield Heat (Left)	0	0	0	0	1
9. Surface Deicer System	0	0	0	0	1
10. Stall Warning Mounting Plate Heater	0	0	0	0	1
11. Wing Ice Light (Left)	0	0	0	0	1
12. Windshield Wiper (Left)	1	1	1	1	1
Instruments (ATA-31)					
1. Clock	0	0	1	1	1

	VFR Day	VFR Night	IFR Day	IFR Night	Icing Conditions
Landing Gear (ATA-32)					
1. Landing Gear Position Indicator Lights	3	3	3	3	3
2. Flap-Controlled Landing Gear Aural Warning	1	1	1	1	1
3. Nose Steering Disconnect Actuator	1	1	1	1	1
4. Landing Gear Hydraulic Pump	1	1	1	1	1
Lights (ATA-33)					
1. Cockpit and Instrument (Required Illumination)	0	1	0	1	0
2. Anti-Collision	0	2	0	2	0
3. Landing Light	0	2	0	2	0
4. Position Lights	0	3	0	3	0
5. Cabin Door Warning Light (Note)	1	1	1	1	1
6. Baggage Door Warning Light (Note)	1	1	1	1	1

Note: Where combined into one cabin/baggage annunciator - one (1) is required for all conditions.

	VFR Day	VFR Night	IFR Day	IFR Night	Icing Conditions
Navigation (ATA-34)					
1. Altimeter	1	1	1	1	1
2. Airspeed	1	1	1	1	1
3. Magnetic Compass	1	1	1	1	1
4. Outside Air Temperature	1	1	1	1	1
5. Attitude Indicator (Gyro stabilized)	0	0	1	1	1
6. Directional Indicator (Gyro stabilized)	0	0	1	1	1
7. Sensitive Altimeter	0	0	1	1	1
8. Turn and Bank Indicator or Turn Coordinator	0	0	1	1	1
9. Vertical Speed Indicator	0	0	1	1	1
10. Navigation Radio (VHF)	0	0	1	1	1
Vacuum System					
1. Suction or Pressure Gauge	1	1	1	1	1
2. Instrument Air System	1	1	1	1	1
Propeller (ATA-61)					
1. Autofeather System	2	2	2	2	2
2. Low Pitch Light	2	2	2	2	2
3. Do Not Reverse Warning Light	1	1	1	1	1
4. Propeller Reversing	2	2	2	2	2

	VFR Day	VFR Night	IFR Day	IFR Night	Icing Conditions
Engine Indicating (ATA-77)					
1. Tachometer Indicator (Propeller)	2	2	2	2	2
2. Tachometer Indicator (Gas Generator)	2	2	2	2	2
3. ITT Indicator	2	2	2	2	2
4. Torque Indicator	2	2	2	2	2
Engine Oil (ATA-79)					
1. Oil Temperature Indicator	2	2	2	2	2
2. Oil Pressure Indicator	2	2	2	2	2
3. Low Oil Presure Light	2	2	2	2	2
4. Engine Chip Detector System	2	2	2	2	2

Note 1: The zeros (0) used in the above list mean that the equipment and/or system was not required for type certification for that kind of operation.

Note 2: The above system and equipment list is predicated on a crew of one pilot.

Note 3: Equipment and/or systems in addition to those listed above may be required by the operating regulations.